PHYSICOCHEMICAL AND HEAVY METAL ANALYSIS OF POTABLE DRINKING WATER PRODUCED AND SOLD IN ILARO, YEWA SOUTH, OGUN STATE

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Abstract

With the recent increase in the consumption of sachet and bottled water in major cities and towns in Nigeria, there are several infections associated with food and water and there is a growing concern for the safety and quality of drinking water. Assessment of physicochemical parameters and heavy metals were carried out in potable water of Ilaro town. Ten samples from five popular sachet water factories were collected directly from the water factories (two per industry). The samples were examined physically and chemically using AOAC standard methods and instrumentation. The values of pH, electrical conductivity (EC), total dissolved solid (TDS) and alkalinity (HCO3) are found to range from (6.14 – 6.82), (81.90 – 169.8), (36.86 – 74.01) and (12.50 – 60.55) respectively. The pH concentrations in two of the samples were found to be lower than World Health Organization (WHO) standard of 6.5 in drinking water. Concentrations of heavy metals (Lead , Manganese, Nickel and cadmium) were determined using atomic absorption spectrophotometer. Some of them were not detected by the instrument, while manganese was found to be above the stipulated limits in some samples. It was concluded that though the value of the pH and manganese concentration in some samples did not fall within the WHO limits, they do not pose any serious health risk to consumers. Generally, the result obtained in this study indicated that the potable water produced and sold in Ilaro were of good quality and hygienic for consumption.

Keywords: Water, Heavy metals, Physiochemical parameters, WHO

Introduction

Water is one of the most valuable natural resource to living creatures, after air, standing as the second most important natural gift to the earth, particularly to all living things, sequel to its universal importance in virtually every aspect of life (Fryar, 2017). About 75% of the earth mass is made up of water found in streams, oceans, lake, springs and even living creatures (plants, animals and organisms). In human beings, water makes up to 65% of the whole body mass, found in the body fluid (blood) with important biological functions such as biochemical and physiological processes which form a platform for enzymes to function effectively to enhance metabolic processes and excretion in the body, hence, contributing to the wellbeing, growth and development of the body mass of living organisms (Shigut et al., 2016).

The usefulness of water cannot be overemphasize, especially safe drinking water. The usefulness of water cut across Agricultural purposes, industrial, habitation for animal, transportation, recreational purposes and power generation (Shugut et al., 2016).

However, the exponential increase or growth of human population in the modern era, have shown a direct effect on the increase in industry, agriculture and other anthropogenic activities of which have direct effect on the demand and quality of drinking water available to the populace. Anthropogenic activities have been identified as the major source of contamination to the water bodies which can be surface or ground water, through the use of chemicals (such as pesticides, persistent organic pollutant), industrial wastes, mining, improper waste disposal etc (Egbeja, Olubiyo & Olabiyo, 2021). These activities have arouse global concerns on safe drinking water to the populace which is defined as water of sufficient quality in terms of physical, chemical and bacteriological which are acceptable factors for safe water suitable for drinking and cooking (WHO, 2015).

One out of every six people have been reported to lack access to safe drinking water, this amount to about 1.1 billion people; in Africa particularly, half of the population lacks access to adequate drinking water, resulting to illness (WHO, 2017, UNDP, 2015). Water burn diseases (cholera, typhoid etc) are part of the major health concern in Nigeria, due to its wide spread in rural areas of some parts of the country and the number of casualties reported in each case. The government has invested in the control of the disease conditions through immunization of children in particular. But still been confronted with the inability to provide enough safe drinking water to their citizens (Augustin et al., 2019; Shigut et al., 2016). Yusuf et al. (2015) stated that regardless of the source, natural water contains impurities through their contact with various form of contaminant in the environment in every form (through accumulation, filtration from soil layers and rock, absorption, dissolution of substances etc).

Alternatively, potable water in the form of packaged water is provided by entrepreneurs all over the country in a quest to solve the problem of insufficient quality water supply from government, though cheap, readily available and accessible. Despite this, the quality of the potable water is a thing of concern, looking at the sanitary environment and condition in which they are provided. Studies have shown that packaged water can be contaminated at various stages of manufacturing and handling having in record, the growing number of ailment as a result of sachet water consumption (Mohammed, Mamude, Amin, Florence & Fatima, 2020; Yusuf et al., 2015).

In Nigeria, government agency such as National food drug administration and control (NAFDAC) saddled with the responsibility of regulating and enforcing compliance with internationally defined drinking water guidelines and standard, is overwhelmed with this challenge, particularly in the fast increasing urban and rural populace and water factories.

However, the generally and widely accepted standard and requirement for drinking water is the WHO stipulated standard (Mohammed et al., 2020). These informed the research to assess the quality of potable water produced and sold in Ilaro, in a quest to contributing to ensuring safe drinking water for all citizens particularly of Ilaro, Yewa South, Ogun State environs.

2.0 METTHODOLOGY

Study area

The study was conducted at Ilaro, a town in Ogun State, Nigeria's south-western region. It is located on longitude 3°00′50″ East and latitude 6°53′20″ North. The population of the town is estimated to be around 57,850 people. Farming, lumber industry, fufu and garri processing are the main activities of the locals. There are also cement plants in the area.

Sample collection

Ten samples of sachet water were collected from five separate water factories. Water samples were obtained in duplicates from each brand; a total of ten (10) water samples were used in this investigation, all of which were labeled appropriately. The sample collection procedure was carried out early in the production day. The samples were stored in ice and in a dark environment to protect the integrity of the water.

Chemicals

All chemicals and reagents(Potassium dichromate indicator, Silver Nitrate, ammonia buffer, eriochrome black T indicator, phenolphthalein indicator, Sodium Hydroxide, Hydrochloric acid, Nitric acid) used for laboratory analysis were of analytical grade.

Determination of physicochemical parameters

The analytical method for physicochemical analysis of the water samples were carried out according to AOAC (2019).

Chloride

50ml of water samples was measured into a clean dried conical flask, 2 drops of potassium dichromate indicator was added. The sample solution in the conical flask was titrated against 0.1M Silver nitrate and the color changed from yellow to a reddish brown color at the end point/

Hardness

50ml of water samples was measured into a clean dried conical flask, 1ml of ammonia buffer was added followed by 2-3 drops of eriochrome black T indicator and the color turned wine red. The sample solution in the conical flask was titrated against 0.01M EDTA until a blue end point appeared.

pH

This was carried out by dipping a calibrated pH meter electrode into the water solution the result displayed on the meter was recorded as the value for the pH of the solution.

Conductivity

This was carried out by dipping a calibrated conductivity meter electrode into the water solution. The result displayed on the meter was recorded as the value for the conductivity of the solution.

Salinity and Temperature

Both analyses were equally carried out on conductivity meter, but by switching to salinity and temperature template.

Total Dissolved Solids (TDS)

50ml of water sample was measured and filtered into a pre dried and weighed beaker. The beaker containing the sample was placed inside the oven until almost a constant weight difference was achieved. The dried beaker containing the residue was removed from the oven and cooled in a desiccator. The weight was taken to ascertain the amount of residue present which was used to calculate the total dissolved solids in mg/L.

Total solids (TS)

50ml of water sample was measured into a pre-dried and weighed beaker. The beaker containing the sample was placed inside the oven until almost a constant is attained. The dried beaker containing the residue was weighed and the amount remained was expressed in part per million (ppm).

The dissolved oxygen

About 50ml of water sample was measured into 100ml of beaker, the DO electrode was dipped into the water and the reading was display on the meter.

Acidity

50ml of water samples was measured into a clean dried conical flask, 2-3 drops of phenolphthalein indicator and the sample solution in the conical flask was titrated against 0.02M Sodium Hydroxide (NaOH) until a pink end point appeared.

Alkalinity

50ml of water samples was measured into a clean dried conical flask, 2-3 drops of methyl orange indicator and the sample solution in the conical flask was titrated against 0.01M hydrochloric acid (HCl) until a color change from orange to purple end point appeared.

Total suspended solid

50ml of water sample was measured filter with a pre-dried and weighed filter paper. The filter paper and residue is oven dried at 105℃ and allows cooling in a desiccator. The filter paper is then weighed to know difference between the initial weight and the final weight.

Digestion for heavy metals

10ml of the water sample was measured into a digestion tube and 15ml of Nitric acid was added to it, the solution was placed into the Q digestion box and heat at temperature of 150^oC for 30-35mins. Allow cooling for 30-60mins and made up to 25ml with distilled water, filtered. The sample is taken to AAS machine for heavy metal readings.

3.0 Results

The values of the physicochemical and heavy metal properties of the five pure water brands

Table 1.0: Physical parameters of the potable drinking water samples from five water factories in Ilaro.

S/N	PARAMETERS	EE		FPI		FD		TT		VP		WHO LIMITS
		A	B	A	B	A	B	A	B	A	B	
1	TEMPERTATURE (^{0}C)	24.5	24.1	23.8	23.9	24.7	25.1	24.3	25.4	24.9	25.2	22-26
2	CONDUCTIVITY (µ/cm)	130.40	136.40	85.98	81.90	103.20	102.70	158.71	169.8	114.80	100.40	400
3	ODOUR	Odorless	Odorless	Odorless	Odorless	Odorless	Odorless	Odorless	Odorless	Odorless	Odorless	Odorless
4	COLOUR	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless
5	TDS (mg/L)	59.98	61.38	37.83	36.86	48.50	46.22	73.01	74.01	50.51	44.18	500
6	TSS (mg/L)	26.78	27.80	35.98	32.65	33.79	29.86	21.08	31.05	28.54	31.09	-
7	TS (mg/L)	86.76	89.18	73.81	69.51	82.29	76.08	94.09	105.06	79.05	75.27	1000
8	SALINITY (mg/L)	0.064	0.067	0.044	0.043	0.052	0.052	0.071	0.081	0.056	0.051	-

The physical parameters of the water samples analyzed as compared with the WHO limits for each parameter are shown in the table above.
KEYWORDS: EE: Eleyele water, FPI: Federal Polytechnic Ilaro water, VP: Vessel of Praise water, FD: Fadcol water, TT: Tailor Tailor water, TDS: Total Dissolved Solids, TS: Total solids.

Table 1.1: Chemical parameters of the potable drinking water samples from five water factories in Ilaro.

S/N	PARAMETERS	EE		FPI		FD		TT		VP		WHO
		A	B	A	B	A	B	A	B	A	B	LIMITS
1	Ph	6.55	6.59	6.25	6.79	6.58	6.56	6.59	6.76	6.14	6.82	6.5-8.5
2	ACIDITY (mg/L)	22.50	24.80	40.00	15.00	25.00	26.5	25.00	15.65	45.00	12.00	-
3	ALKALINITY (mg/L)	20.50	20.56	15.50	26.80	22.60	60.55	23.60	35.70	12.50	55.05	500
4	CHLORIDE (mg/L)	35.50	30.52	53.48	35.50	53.50	35.50	27.65	34.7	35.05	53..3	250
5	TOTAL HARDNESS(mg/L)	3.05	3.07	2.80	3.16	1.85	2.90	2.70	2.56	2.86	3.16	200
6	DISSOLVED OXYGEN (mg/L)	7.45	8.65	7.78	8.22	8.15	7.34	7.50	8.54	8.05	7.76	> 7.0
7	CALCIUM (mg/L)	1.22	1.23	1.12	1.26	0.74	1.16	1.08	1.02	1.14	1.26	100
8	MAGNESIUM (mg/L)	1.83	1.84	1.58	1.90	1.11	1.74	1.62	1.54	1.72	1.90	100

The chemical parameters of the water samples analyzed as compared with the WHO limits for each parameters are shown in the table above.
KEYWORDS: EE: Eleyele water, FPI: Federal Polytechnic Ilaro water, VP: Vessel of Praise water, FD: Fadcol water, TT: Tailor Tailor water

Table 2.0: Heavy metal of the potable drinking water samples from five water factories in Ilaro.

S/N	PARAMETERS	EE		FPI		FD		TT		VP		WHO LIMITS
		A	B	A	B	A	B	A	B	A	B	
1	LEAD (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
2	IRON (mg/L)	0.056	0.058	0.156	0.021	0.087	0.053	0.196	0.036	0.087	0.045	0.30
3	CADMIUM (mg/L)	0.00	0.004	0.00	0.00	0.00	0.002	0.00	0.001	0.00	0.00	0.005
4	ZINC (mg/L)	0.670	1.106	1.052	0.865	0.865	0.789	1.085	0.972	1.065	0.920	2.0
5	NICKEL (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001
6	CHROMIUM (mg/L)	0.007	0.00	0.00	0.022	0.015	0.00	0.00	0.00	0.00	0.00	0.05
7	MANGANESE	0.016	0.035	0.011	0.046	0.017	0.017	0.018	0.00	0.022	0.008	0.020

The heavy metals parameters of the water samples analyzed as compared with the WHO limits for each parameter are shown in the table above. Each of the samples was analyzed for seven (7) heavy metals, namely, iron, lead, zinc, nickel, chromium, and manganese. The result obtained shows conformity to standard in all but manganese where three samples have a value higher than the WHO limit.
KEYWORDS: EE: Eleyele water, FPI: Federal Polytechnic Ilaro water, VP: Vessel of Praise water, FD: Fadcol water, TT: Tailor Tailor water

4.0 Discussion

Each of the samples collected was analyzed for heavy metals and physicochemical properties, namely, pH, temperature, conductivity, odor, color, total dissolved solid, total suspended solids, total solids, salinity, acidity, alkalinity, chloride, total hardness, dissolved oxygen, calcium, magnesium, lead, iron, cadmium, zinc, nickel, chromium, and manganese.

Physical parameters

Table 4.1 presents the laboratory results of all examined physical properties as compared with the WHO standard values for safe drinking water.

The assessment of organoleptic attributes (color, taste, and odor) showed all the samples to be clear with no taste or smell. These determine the aesthetic value (i.e. pleasantness, palatability and acceptability of the water) (Yusuf et al., 2015). These are expected as many of the industries get their water supply from boreholes and pass it through industrial and micro-filters, this finding also agree with the result of Alhassan, Imam and Yakasai (2008).

The standard temperature of potable water according to WHO is 25^0C though the acceptable limit ranges from 22^0C to 26^0C. The result of the water samples analyzed shows the lowest value 23.9 mg/L and the highest value 25.2 mg/L which is within the WHO acceptable limits.

The electrical conductivity, total dissolved solids (TDS), and total suspended solids (TSS) range between 81.90 mg/L - 158.71 mg/L, 36.86 mg/L – 73.01 mg/L, 26.78 mg/L - 35.98 mg/L respectively for the samples. The desirable limits as stipulated by WHO is 500 mg/L for TDS and 1000 mg/L for TSS while no limits has been stipulated for conductivity. The result obtained from the analysis indicates that values of electrical conductivity, total dissolved solids, and total suspended solids are all within the WHO stipulated limits. Conductivity is always related to the amounts of solids in water, and a pure water is a poor conductor of electricity (Ujile, Abam, Ngah & Ibinabo, 2021). High values of total suspended solids supports the growth of bacteria as they act as point of attachment for bacteria (Ejike, Ohaeri & Amaechi, 2021). The source of conductivity may be an abundance of dissolved salts via mineral discharge from wastewater and soil sediments. However, it does not have a direct impact on human health, but can reduce the aesthetic value of the water by giving it a mineral taste. The value of the TDS indicate the amounts of dissolved substances or pollutants in the water, this also serves as a factor in determining the level of pollution in water.

Drinking water salinity has been linked to risk of preeclampsia and gestational hypertension. Increase in salinity in groundwater can be caused by over extraction of groundwater (Kanwal et al., 2017). The salinity obtained for the water samples analyzed were low for all samples. This implies that the water samples are good for consumption with respect to salinity.

Chemical Parameters

The pH is a measure of the acidity and alkalinity of water. It is measured on a scale which ranges from 0 to 14. Values below 7 are acidic while values above 7 are basic. The values of the samples are found to range from 6.14 – 6.82, where the lowest and highest values are from VP and TT respectively. These values shows slightly acidic trend. From the above result, two of the samples analyzed (FPI A & VP A) were discovered to be below the acceptable range (6.5-8.5) set by WHO. The low pH level discovered in VP A and FPI A may be an indicator of high levels of free CO_3 which may consequently affect bacteria count, affect the gastrointestinal tract, cause diarrhea and tuberculosis as well as affect the toxicity of poisons when consumed (Ayedun et al., 2012). FPI B and VP B were both found to be within the stipulated range with 6.59 and 6.82 respectively. The variation in the pH values is due to change in the values of CO_3, carbonate and bicarbonate in water (Ejike et al., 2021). This phenomenon may arises from use of different tanks or different boreholes in the factories where one water sources is contaminated and the other is free from contamination.

Calcium and magnesium levels in water determine the hardness of the water (Ejike et al., 2021). Water hardness depends on anions such as bicarbonate, sulphate and chloride and major cation such as calcium and magnesium (Fadaei & Sadeghi, 2014). The result obtained revealed the values of calcium and magnesium salt to range from 0.74 mg/L – 1.26 mg/L, and 1.11 mg/L – 1.90 mg/L respectively. This shows that all water samples analyzed are soft water and the total hardness of all the water samples are all within the standard limits for hardness in drinking water. The minimum and maximum values for calcium values were obtained from FD A and VP B respectively while the minimum and maximum values obtained for magnesium were from FD A and VP B. This implies that FD A is better

water with respect to total hardness. The presence of these ions in water may be attributed to the recharge of water containing the ions from the ground and the high solubility of water for rocks, lime stones and gypsum. Magnesium and calcium is important in metabolic activities in the body and also takes part in other physiological processes.
High chlorine in drinking water elicit a chronic toxicity in humans. According to Ujile et al. (2021), cancer risk among people drinking chlorinated water is 93% higher than those who drink water without chlorine. The values obtained for chloride as indicated in the table 4.2 above shows that the chloride levels for all water samples analyzed are within the stipulated limits. The presence of high level of chlorides in water may be an indicator of contamination by waste water and lower levels may indicate the contrary. The sources of chloride in water could be attributed to the dissolution of chloride containing minerals and rocks when water comes in contact with them (Popoola et al., 2019). Excessive chloride concentrations of about 250 mg/L can give rise to detectable taste in water, and the threshold depends upon the associated cations (WHO, 2017).

Alkalinity of water is its acid neutralizing capacity. It is mainly caused by the presence of hydroxide ions, bicarbonate ions and carbonate ions. The values give an idea of the level of natural salts present in water. The alkalinity level obtained for the water samples ranges from 12.50 – 60.55 (mg/L). These values are well within the maximum acceptable limits in drinking water (500mg/L). However, it is worthy to know that low alkalinity causes corrosion of pipes and increases the chance for releasing many heavy metals (Jingxi et al., 2020).

Heavy metals

Each of the samples was analyzed for 7 heavy metals, namely, iron, lead, zinc, nickel, chromium, and manganese. **Table 4.3** presents the results of the heavy metal analyzed as obtained from the laboratory. Lead and nickel was not detected in all water samples; this could mean that they contained no lead and nickel or they were present in the samples in an amount that could not be detected. Chromium and cadmium were detected in only three water brands (EE A, FPI B, FD A) and (TT B, FD B, EE B) respectively, while the other metals were detected in all samples.
Iron as a trace element was detected in all samples, and its value ranges from 0.036 (mg/L) – 0.196 (mg/L). These observed values are low compared to the maximum recommended limit stipulated by WHO for safe drinking water. Iron is one of the essential elements in human nutrition as it plays a major role in human physiology and metabolic activities. Deficiency in iron has been attributed to cardiovascular collapse, vomiting, diarrhea and failure of blood clotting (Ma et al., 2020).

From the result obtained, the maximum and the minimum zinc levels obtained were 0.670 mg/L and 1.106 mg/L from FD and TT respectively. All examined samples revealed zinc concentration below the limit of 2.0 mg/L set by the WHO. This could be that zinc in its natural mineral form did not dissolve into the water sources via leaching (Popoola et al., 2019). Zinc plays an important role in a variety of enzyme system which contributes to energy metabolism, transcription and translation.

Chromium and cadmium were detected in EE, FPI and FD. However, the samples were discovered to be below the maximum limit (0.05 and 0.005 mg/L respectively) stipulated by the WHO. Epidemiological studies have shown that long-term exposure to cadmium and chromium could cause kidney damage, lung cancer, bone defects, and high blood pressure (Popoola et al., 2019).

The result obtained for manganese ranges from 0.00 – 0.046 mg/L. This revealed three of the water samples to have a concentration that is slightly above the permissible limit stipulated by WHO, EE A, FPI A, FD A, FD B, TT A and VP B all have values below the maximum acceptable limits while it was not detected in TT B. The three samples with high values are EE B with 0.026 mg/L, FPI B with 0.028 mg/L and VP B with 0.022. These are above the stipulated limits of 0.020 mg/L. This observation could be due to water (from the source) contact with dissolved soil, rock and minerals of manganese, leachate from landfill and sewage deposited over time (Popoola et al., 2019). High manganese concentrations in water give the water an unpleasant taste. However, no record of health risk has been recorded in humans as a result of excess manganese exposure (Takeda, 2003).

5.0 Conclusion

The present study was carried out to assess the physical, chemical and biological properties of sachet water in Ilaro Area of Ogun State. A total of ten samples were selected for the analysis. The results from the laboratory analysis showed that most of the physicochemical parameters conformed to WHO limits except VP A and FPI A where the pH is slightly below the requirement. Also, the results of the heavy metals analysis showed that all the water samples passed the heavy metals quality parameter except in FPI B,VP A and EE B whose values were slightly above the W.HO. Limit meant for manganese.

The overall results showed that the sachet water produced in the study area were relatively safe for drinking according to the World Health Organization standards for potable water.

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